1502

STUDY OF THE EFFECT OF THE ELASTIC TISSUE OF HIDE ON THE PHYSICAL PROPERTIES OF LEATHER*

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ABSTRACT

This paper is a report of the results of over two years of laboratory and plant work in developing a method for removing elastic tissue from cowhide under controlled conditions and in studying the effects of such removal on the physical properties of the leather produced. The evidence is conclusive that removal of elastic tissue from cowhides by means of Viokase enzyme causes the leather produced from such stock to have softer temper, coarser break, and more drawn grain than the corresponding control leather. Physical tests indicate that the removal of elastic tissue from cowhide stock caused the leather produced from such stock to have higher tensile strength and higher stitch tear strength as well as a more flexible grain.

INTRODUCTION

Much of the present knowledge about elastic tissue has been summarized by Highberger (1), who states that elastic tissue appears in most connective tissues of the body, is yellow in color in the native condition, and is found in close association with collagen. Small quantities of elastic tissue are present in the skin, mostly in the grain and the flesh layer, where the tissue exhibits a characteristic branching form, and in the arterial system. Elastic

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tissue is extremely resistant to water and can be boiled with no apparent effect. It is much more resistant than collagen to acids, alkalies, and some enzymes.

In determining the properties of elastic tissue, most of the work has been done on elastin-rich material such as the neck ligaments of cattle and large arteries. It is comparatively easy to purify the elastic tissue in these materials by extracting everything else, leaving the purified elastic tissue as a residue. Interest in removal of elastic tissue in skin without damage to the associated collagen probably received its greatest impetus from the work of Roddy and O'Flaherty (2) who showed that the elastic tissue in calfskin is not appreciably affected by any of the pre-tanning operations but becomes hard and brittle after tanning and drying.

Following this work, Pleass (3) concluded from a microscopic study of finished glove leather that, although elastic tissue is present in a broken-down state, it has no correlation with the degree of run of glove leather. White and Caughley (4) concluded that elastic tissue fibers do not perform an important part in the tightness of grain during the wet process but may play an important role in the tightness of dry leather. The present work is the first attempt to correlate the physical properties of finished leather with the removal of definite amounts of elastic tissue.

In work done at the Eastern Utilization Research Laboratory of the Department of Agriculture, Hoover *et. al* (5) have been able to isolate the grain layer of bovine skin and have found it to have properties very close to those of elastic tissue. Mellon and Korn (6) at the same laboratory demonstrated by means of horizontal sectioning and chemical fractionation that this condensed grain membrane was the result of the collapse of the 3-dimensional network of elastic tissue fibers as usually seen in the microscopic examination of stained cross sections of skin. The problem at hand then becomes one of measuring by chemical or physical means any changes in the amount of the elastic tissue and relating such changes to the physical properties of the leather produced from such modified skins.

Almost forty years ago Wilson (7) advanced the idea that the chief function of the enzyme in the bate was the removal of elastic tissue. He and co-workers were able to demonstrate by means of cross sections of calfskins before and after bating that the removal of elastic tissue was a function of concentration of enzyme and time. However, Hollander (8) showed by histological study of bated skins that the elastin fibers are not completely removed by bating action. More recently the dissolution of elastic tissue by the enzyme elastase has been studied by Balo and Banga (9) and by Hall and Gardiner (10). They used elastic tissue which they prepared from aorta and ox ligamentum nuchae. They found that elastic tissue from these sources could be dissolved by elastase derived from pancreatic extract. More than 70 per cent of their elastic tissue preparations was dissolved. Hoover, *et*

al. (5) found that the grain membrane which they identified as elastic tissue could be dissolved by trypsin. In the present work the elastic tissue was removed from skin and hide by use of a pancreatic product.* The elastase activity of this product, when measured by the formol titration method of Cordon *et al.* (11) at a concentration of 167 mg. of enzyme per 100 ml. of solution at pH 8.5, was 7.64 meq. of nitrogen liberated per gram of enzyme. The protease (PV) activity measured by the Gross-Fuld method (12) was 81,500 PV units per gram of enzyme at pH 7.0.

EXPERIMENTAL PROCEDURE

General Considerations

Limed hide, ready for bating, contains essentially water, lime, lipids, collagen, hair-root debris, some globular protein, and elastic tissue. The development of a method of measuring the amount of elastic tissue in limed hide then involves purifying the relatively inert elastic tissue by removing the associated components. Only the hair-root debris offers any serious difficulty in the process of purification, since the other components are soluble in water, acid, and fat solvent. Tancous (13) has shown that the elastic tissue-keratin residue amounts to only 2.4 per cent of the total protein on a nitrogen basis in pickled calfskin. The nitrogen basis was also used by Hoover, *et al.* (5) in determining the amount of the grain membrane previously cited, which also contained hair-root debris. Stubbings (14) also used the nitrogen basis in his calculations in his attempt to separate the elastic tissue and hair-root fractions by means of treatment with sodium sulfide.

Since the interest of the present investigation is in the measurement of the loss of elastic tissue from the hide, the presence of hair-root debris in the purified residue becomes unimportant if its distribution in the hide under test can be shown to be uniform. Such considerations led to the use of the dry weight of the purified elastic tissue-keratin residue, expressed as a per cent of the dry weight of the limed or bated hide, as a basis for calculating the loss of elastic tissue due to enzymatic action.

Purification of Elastic Tissue-Keratin Residue

The use of the autoclave (6) enables one to dissolve the collagen from the limed hide in a reasonable length of time without affecting the elastic tissue. Time-rate studies using the hydroxyproline assay to determine when all of the collagen had been removed from the residue were used to establish the minimum time required. The resulting grain membrane in a solution of

*The product, called Viokase, was a commercial preparation from a whole raw pancreas which had been activated, desiccated, and defatted. This product was manufactured by the Viobin Corporation, Monticello, Illinois. The mention of trade names or companies does not constitute an endoresment of the Department of Agriculture over other products of a similar nature not mentioned.

gelatin was then filtered while hot and washed free of soluble proteins and lime by alternate washes with hot water and hot dilute acid. Lipids were then removed by extracting with acetone. The detailed method is as follows:

1. Press representative squares of limed hide or skin, approximately 1½" in size, individually in a Carver press at 10,000 pounds ram pressure to remove most of the water.

2. Dry the squares in a vacuum oven at 22" of mercury and at 80° C. overnight to furnish a dry-weight basis.

3. Add sufficient distilled water to make a 2-3 per cent gelatin solution assuming all of the dry weight is collagen. Autoclave at 15 pounds pressure for four hours.

4. Filter while hot through tared, coarse-fritted glass crucibles and wash free from lime and soluble proteins using alternate washes of hot water and hot 0.5*N* HCl. Finally wash free of acid with hot water. Suction may be used but in some cases may cause the filter to clog.

5. Place the crucibles in Soxhlet apparatus, and extract with acetone for four hours.

6. Air-dry to remove acetone, and finally dry in a desiccator to constant weight. An overnight period is satisfactory.

Laboratory Tests to Remove Elastic Tissue

A side of heavy cowhide was obtained from a tanner of side upper leather. This side had gone through the regular soaking and beamhouse operations including unhairing and fleshing. It was received in a wet condition, wrapped in a plastic bag. The side was large enough to permit marking the pattern of specimens shown in Figure 1. After numerous preliminary tests the following procedure was used on the test specimens:

1. Place 10 specimens in a jar with water volume equal to 3 to 1.

2. Surface delime with 0.75 per cent HCl for ½ hour at 75° - 77° F. The end pH of the liquid should be neutral to methyl orange.

3. Add 2.25 per cent boric acid, and run for one hour.

4. Let stand overnight to delime completely.

5. Start heating, and add 1.5 per cent borax. Run for ½ hour. The pH should be 8.5 to 9.0 and the temperature 90° F.

6. Add pancreatic product, and treat for the required time at 90° F.

7. Remove the specimens, blot on towels, wrap in groups of ten, and store in the freezer until needed. Then proceed as previously described under purification of elastic tissue-keratin residue.

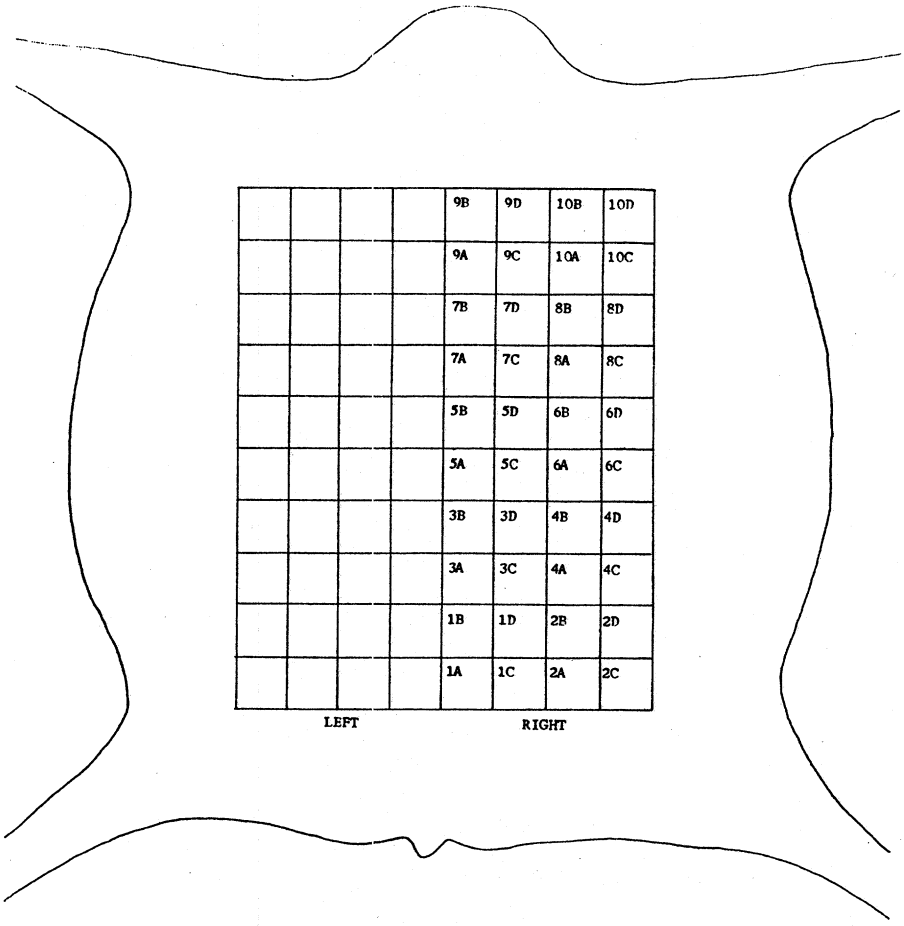

FIGURE 1.—Distribution of sample squares within a skin.

Pilot-Plant Test for Removal of Elastic Tissue

In the pilot-plant test 60 matched sides were used. Thirty sides (even lefts and odd rights) were selected from the 60 matched sides for three elastic tissue removal experiments as follows:

Lot A-7 0.05 per cent pancreatic product, 10 sides.
Lot A-8 0.10 per cent pancreatic product, 10 sides.
Lot A-9 0.20 per cent pancreatic product, 10 sides.

The 30 sides which matched the above 30 experimental sides were used as controls. Three pairs of matched sides were used to compare regular production wash and bate procedure with special deliming procedure used on all of the above 60 sides.

Treatment of lot A-7—Even left and odd right sides numbered 1-10 weighing 250 pounds were treated as follows:

1. Floated and washed 5 minutes at 75° F.
2. Drained.
3. Floated at 300 per cent (90 gals.) at 75° F.
4. Added 0.75 per cent (1 pound, 14 oz.) HCl in 3 gals. water at 75° F. and ran 30 minutes at pH of liquor 6.0 to 6.5. (This procedure was used to clear the grain surface of stains.)
5. Added 2.25 per cent (5 pound, 10 oz.) boric acid and ran one hour. pH of liquor 7.2.
6. Rested overnight to delime. pH of liquor 8.0.
7. Removed stock and heated liquor with live steam to 97° F., turned the drum and added stock, turned the drum again, at 93° F. 1.25 per cent borax was added with stock. pH of liquor 8.5 to 9.0.
8. Added 0.05 per cent pancreatic product (2 oz.). Ran 2 hours. pH of liquor 8.5 to 9.0.
9. Drained and floated and washed 10 minutes at 75° F.
10. Transferred to production drum with controls for pickle and chrome tan.

Treatment of lot A-8—Even left and odd right sides numbered 11-20 weighing 248 pounds were run the same as Lot A-7 except for the use of 0.10 per cent pancreatic product in step No. 8.

Treatment of lot A-9—Even left and odd right sides numbered 21-30 weighing 250 pounds were run the same as Lot A-7 except for the use of 0.20 per cent pancreatic product in step No. 8 and a run of 4 hours instead of 2 hours. Note: Three lefts, numbers 31, 32, and 33, were bated, pickled, and chrome-tanned with regular production and put with experimental and control sides for succeeding operations.

Treatment of controls to lots A-7, A-8, A-9—Odd lefts and even right sides numbered 1-30 and right sides 31-33 weighing 847 pounds were handled the same as Test Lots A-7, A-8, and A-9 up to step No. 8. At step No. 8 they

were bated with 0.75 per cent Oropon FS and run 45 minutes at 92° F. Steps 9 and 10 were the same as the treatments for test lots A-7, A-8, and A-9.

The experimental and control sides were then pickled and chrome-tanned using the regular production procedure. When the chrome had completely penetrated the stock, the chrome was set with sodium bicarbonate at pH 3.40 using 0.7 per cent sodium bicarbonate instead of the regular 0.5 per cent because less acid was neutralized by the completely delimed stock. The shrinkage temperature of the stock was 212° F. after the chrome was set. The stock was fatliquored and finished as a brown pigmented finished leather.

In the crusted state and as finished leather the stock was examined by experienced sorters for evaluation of the stock. The finished leather was shipped to the laboratory where analyses and physical tests were conducted to determine what influence the removal of the elastic tissue had on the finished leather. The results obtained and a discussion of the results are given in the following section.

RESULTS AND DISCUSSION

In Table I the results of the laboratory tests for removing elastic tissue from cowhide are given. The elastic tissue-keratin residue was reduced sufficiently in each case to indicate that plant tests should produce leather with variable amounts of elastic tissue. The thickness of the stock was found to have an appreciable effect on the efficiency of removal.

Three sets of ten sides each, representing the three levels of pancreatic product concentration, were compared with their alternate sides as controls. In the physical tests the differences between pairs were used to interpret the significance of the effects of the enzyme. In some cases only the average values are given in the tables in order to reduce the voluminous data. Averages were then compared on the basis of between- and within-skin variances. The usual "*t*" test data are also available for comparison of any two groups.

Table II shows the per cent decrease in elastic tissue for each side. It is obvious that much greater efficiency of removal of elastic tissue was produced in the plant test compared with the previous laboratory work. This may be attributed to the greater "mill" action obtained in the plant which literally pumped the reacting solution through the hides. In any case there is no doubt that most of the elastic tissue has been removed from the test sides. This was also verified by a study of stained cross sections. At the .05 per cent level of pancreatic product in the plant runs, this concentration removed 64 per cent of the elastic tissue from the cowhide over that obtained with the regular bating procedure.

TABLE I

PER CENT ELASTIC TISSUE RESIDUE REMAINING IN MATURE COWHIDE AFTER TREATMENT WITH A PANCREATIC PRODUCT

Location of block in the skin	Per Cent Pancreatic Product			
	0% (control)	0.03% (2 hours) No. 1	0.10% (2 hours) No. 2	0.20% (4 hours) No. 3
A	1.31	0.90	0.66	0.31
B	2.16	1.99	0.68	0.61
E	0.98	0.92	0.49	0.29
G	1.24	1.43	0.89	0.31
H	1.28	1.17	0.63	0.23
J	1.75	2.33	0.97	0.59
K	1.05	0.88	0.69	0.30
L	1.92	1.20	0.68	0.45
M	0.93	0.80	0.69	0.24
N	1.24	1.06	0.72	0.38
O	1.24	0.91	0.46	0.30
P	1.34	1.08	0.82	0.38
R	1.16	1.50	0.70	0.37
S	1.20	1.05	0.88	0.40
T	1.16	1.02	0.76	0.33
U	1.20	1.39	1.01	0.48
W	0.99	0.92	0.44	0.34
X	1.22	1.03	0.90	0.39
Y	0.88	0.66	0.41	0.18
Z	1.98	0.97	0.91	0.28
Average	1.31	1.14	0.72	0.36
Standard Deviation	0.36	0.40	0.18	0.11
Per cent decrease in residue		13.0%	45.0%	72.7%

Tables III and IV show the results of the laboratory evaluation of crust and finished side leather. Methods (15) have been developed at this laboratory for the measurement of such practical values as temper, mellowness, and break. These laboratory measurements have been reported to correlate with plant evaluations of the same properties. No significant effect of enzyme action on temper is shown in any of the two tables, although there is a trend toward more firmness for control leathers. The measurement for mellowness shows inconsistency of significance but in no case shows more than 4 per cent difference between averages and would therefore indicate no practical effect of pancreatic product treatment. In the measurement of break, which shows

TABLE II

PER CENT DECREASE IN ELASTIC TISSUE RESIDUE AFTER TREATMENT WITH A PANCREATIC PRODUCT

Side Leather Stock

Side No.	Low Level 0.05% (2 hours)	Side No.	Medium Level 0.10% (2 hours)	Side No.	High Level 0.20% (4 hours)
1	74.1	11	75.2	21	81.5
2	26.6	12	82.6	22	85.5
3	62.7	13	75.3	23	79.1
4	75.1	14	91.3	24	83.6
5	70.1	15	77.3	25	89.6
6	58.9	16	86.8	26	80.1
7	43.4	17	76.4	27	84.0
8	69.2	18	90.1	28	76.3
9	74.6	19	86.0	29	83.3
10	82.5	20	80.1	30	77.8
Average	63.7		82.1		82.1

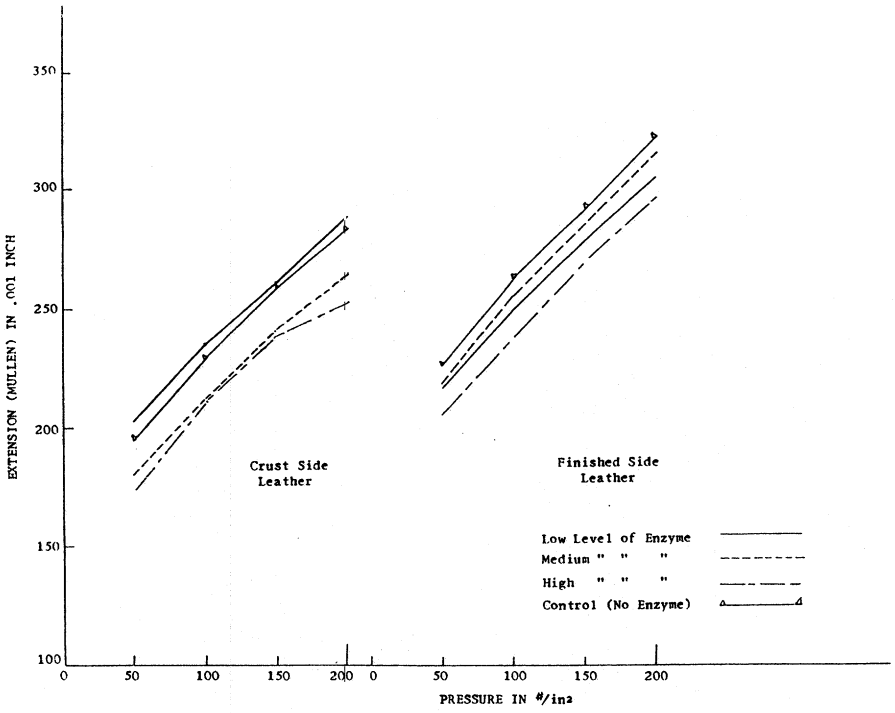

FIGURE 2.—Average Mullen stress-strain values.

TABLE III

LABORATORY EVALUATION OF EFFECT OF ELASTIN REMOVAL ON THE PHYSICAL PROPERTIES OF LEATHER

Crust Side Leather
(Average values)

	Low Level of Pancreatic Product (0.05%)		Medium Level of Pancreatic Product (0.10%)		High Level of Pancreatic Product (0.20%)	
	Test	Control	Test	Control	Test	Control
Temper Values (Compressometer)	39.8	41.0	36.2	38.0	41.9	43.8
Mellowness (Hardness Gauge)	81.8	80.8	80.8*	82.8	80.5	79.3
Break (Hopton Machine)	21.5	20.0	19.4	19.4	19.5*	23.0
Stitch Tear Lbs./in.	1167*	1017	884	877	997	964
Mullen Tests Pressure at Grain Crack	502	424	392	346	492*	332
Permanent Set (in .0001")	186	180	156*	184	146	153
Extension at 200 lbs. Pressure (in .001")	289	284	266*	297	254	272
Tensile Tests (Full Thickness) Lbs./in.^{2}	3766*	3141	2758*	2397	3473*	2650
Per Cent Extension at Break	32.8	37.0	29.5	26.4	31.6	30.3
Pounds Pull at 1st Cycle	89.1*	73.4	76.3	70.3	82.8	76.1
Tensile Tests (Grain Only) Lbs./in.^{2}	2940*	2505	2946*	2543	2862	2712
Per Cent Extension at Break	20.6*	18.0	21.4	19.1	21.3	19.8
Pounds Pull at 1st Cycle	13.1*	14.9	11.9	15.9	13.7*	16.8
Tensile Tests (Corium Only) Lbs./in.^{2}	3375	2868	2390	2094	2636	2462
Per Cent Extension at Break	38.7	39.0	37.8	36.4	34.4	39.4
Pounds Pull at 1st Cycle	56.2	49.9	40.2	35.1	50.6*	43.1

*Indicates Statistical Significance.

TABLE IV

LABORATORY EVALUATION OF EFFECT OF ELASTIN REMOVAL ON THE PHYSICAL PROPERTIES OF LEATHER

Finished Side Leather
(*Average values*)

	Low Level of Pancreatic Product (0.05%)		Medium Level of Pancreatic Product (0.10%)		High Level of Pancreatic Product (0.20%)	
	Test	Control	Test	Control	Test	Control
Temper Values (Compressometer)	26.0	28.0	27.0	25.0	29.3	30.0
Mellowness (Hardness Gauge)	78.3*	76.3	77.2	77.1	83.0*	80.0
Break (Hopton Machine)	56.0	58.8	53.1	56.2	51.3*	63.2
Stitch Tear Lbs./in.	1232*	1114	1062*	928	1108	1082
Mullen Tests Pressure at Grain Crack	522	467	455*	385	563*	445
Permanent Set (in .001")	165	168	160*	175	149*	166
Extension at 200 lbs. Pressure (in. .001")	307	316	315	329	297*	322
Tensile Tests (Full Thickness) Lbs./in.^{2}	3278	3181	2928*	2614	3376*	2903
Per Cent Extension at Break	47.1	46.5	44.4	44.8	43.3	45.9
Pounds Pull at 1st Cycle	57.7	56.8	55.2	49.8	62.3*	52.7
Tensile Tests (Grain Only) Lbs./in.^{2}	1929	1962	2166	1954	2078	1857
Per Cent Extension at Break	33.2	30.6	29.2	27.6	30.6	28.1
Pounds Pull at 1st Cycle	13.5	17.3	16.9	18.4	16.0	17.3
Tensile Tests (Corium Only) Lbs./in.^{2}	2821	2825	2046	1860	2285	1912
Per Cent Extension at Break	43.0	48.5	39.6	40.7	35.9	39.5
Pounds Pull at 1st Cycle	38.7	33.6	30.6	26.3	35.8	27.3

*Indicates Statistical Significance.

the average width of the wrinkles produced by flexing, finer break is indicated by lower values. Here again the results are inconsistent for crust side leather but show a tendency for finer break for the test leathers of finished side leather. The average stitch tear strength of pancreatic product treated side leather is consistently higher than that of the controls but not always at a significant level.

Stress-strain studies were made of all the leathers in two different ways, and the results are shown in Tables III and IV, as well as in Figures 2, 3, and 4. The Mullen Tester was used in one study to obtain the vertical extension of the leather sample while it was held between the clamps and hydraulic pressure was applied to the flesh side. The vertical extensions at 50 pounds, 100 pounds, 150 pounds, and 200 pounds pressure were noted as shown in Figure 2. The pressure was then released, and the extension remaining after one minute of rest was recorded as the permanent set. Pressure was then applied again to determine the pressure required to crack the grain. As shown in Figure 2 no appreciable effect of enzyme treatment and no consistency was shown for any of the leathers. It is interesting to note that none of the curves cross. The pressure at grain crack as shown in the tables is consistently higher for test leathers. The permanent set in most cases is lower for pancreatic product–treated cowhide leathers. The extension at 200 pounds pressure is generally less for the pancreatic product–treated cowhide leathers although not always to a significant degree.

The Instron machine was used to study the stress-strain characteristics of dumbbell samples of $\frac{1}{2}''$ width. Two cycles were used. In the first cycle the jaws pulled the sample at the rate of 10″ per minute to extend it 25 per cent, and then it was returned to the starting position. After one minute of rest the sample was broken on the second cycle using the same jaw speed. The force being exerted on the specimen at all times was recorded automatically on the chart of the machine, and the stress-strain values shown in Tables III and IV and Figures 3 and 4 were obtained from these data. Since most of the elastic tissue of hide is concentrated in the grain, it was considered advisable to study the stress-strain characteristic of the grain and corium separately in addition to the study made of the full thickness.

If we consider the low, medium and high levels of pancreatic product treatment in Figure 3, curves of all three of the full-thickness enzyme-treated leather groups show that more force is required to extend leather from which the elastic tissue has been removed. This agrees also with the results of the Mullen test. The tensile strength of all the full-thickness leathers is consistently higher for the test leathers than for the controls, although not always at significant levels, as shown in Tables III and IV. This is also true for the grain and corium splits of the crust leather but not consistently so for the finished leathers. No consistency is shown for the per cent extension at break for any of the full-thickness leathers, but the grain split values indicate

that elastic tissue removal permits greater extension before breaking. Pounds pull at 25 per cent extension at the end of the first cycle shows that full-thickness side leathers and their corium splits require more force to stretch for the test leathers than for the controls but that the opposite is true for the grain splits. This same effect is shown in Figure 4 for finished side leather.

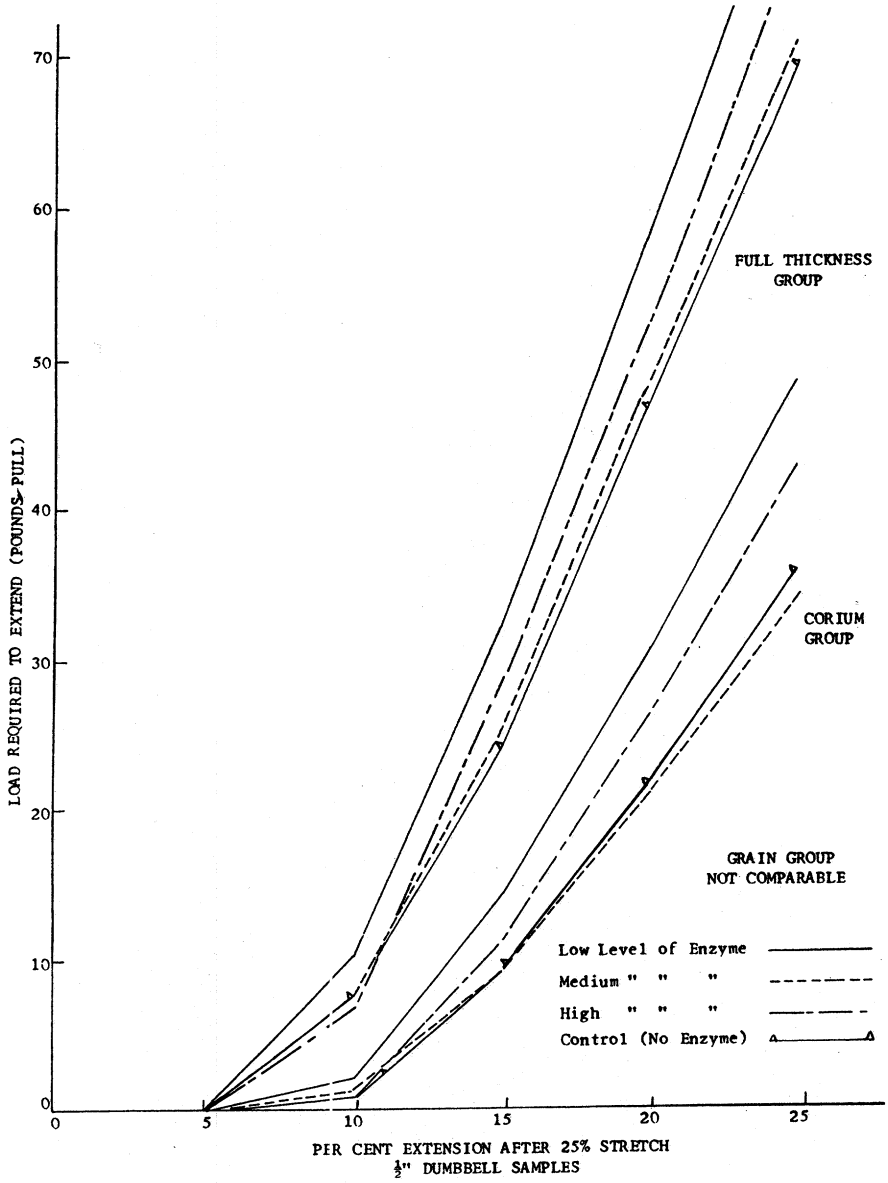

FIGURE 3.—Crusted side leather average stress-strain values (Instron).

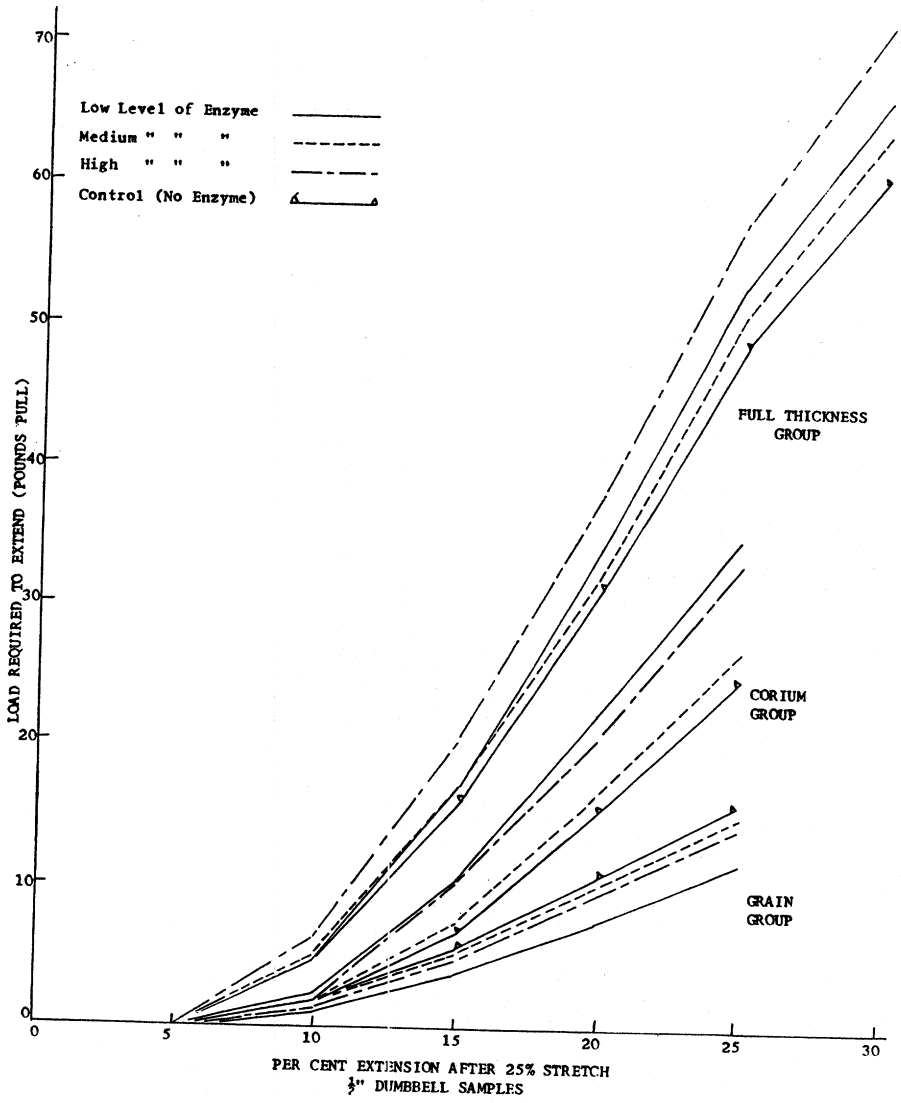

FIGURE 4.—Finished side leather average stress-strain values (Instron).

The plant evaluation of practical physical properties of each side of cowhide leather is shown in Tables V through IX. The average of two or three sorters' opinions is given in the tables. It should be kept in mind as shown by the key at the bottom of each table that higher values mean better temper and break. High values also indicate poorer selection and grain character. Sides 31, 32, and 33 were not part of the main experiment and involved no use of the pancreatic product. They were included to show the effects of

TABLE V

AVERAGE TEMPER EVALUATION BY PLANT SORTERS

Side Leather

Side Number	Level of Pancreatic Product	After Staking (average of 2)		After Buffing (average of 2)		After Finishing (average of 4)	
		Test	Control	Test	Control	Test	Control
1	Low	2.3	4.0	2.8	4.0	1.5	4.3
2	"	4.0	4.0	4.0	4.0	3.8	4.3
3	"	2.8	4.0	3.5	4.0	2.7	4.7
4	"	3.5	3.8	3.5	3.5	3.5	2.5
5	"	4.0	4.0	3.8	4.0	3.8	4.7
6	"	4.0	4.0	3.5	4.0	4.0	3.8
7	"	3.3	4.0	4.0	3.5	2.7	4.2
8	"	4.0	4.0	3.5	4.0	3.5	3.8
9	"	2.8	4.0	3.5	4.0	3.5	5.0
10	"	4.0	3.3	4.0	4.0	3.8	4.3
11	Medium	4.0	4.0	4.0	3.5	4.3	4.2
12	"	3.3	2.8	4.0	3.3	2.7	3.5
13	"	3.3	4.0	2.8	4.0	4.2	2.5
14	"	3.8	4.0	3.5	3.5	2.5	3.7
15	"	3.8	3.8	3.8	3.8	2.8	3.2
16	"	3.5	—	3.5	—	3.2	—
17	"	4.0	4.3	4.0	4.0	4.0	3.8
18	"	3.5	3.3	3.5	2.8	3.0	1.5
19	"	3.5	3.8	2.8	4.0	1.2	2.2
20	"	3.8	4.0	3.8	4.0	3.8	4.3
21	High	3.3	4.0	3.8	4.0	2.3	4.7
22	"	4.0	4.0	4.0	4.0	4.7	4.3
23	"	3.3	4.0	2.8	4.0	3.3	4.5
24	"	4.0	4.0	4.0	4.0	3.5	3.5
25	"	3.5	4.0	3.5	4.0	3.0	4.2
26	"	3.5	4.0	3.5	3.5	2.8	4.0
27	"	3.3	4.0	3.3	4.0	3.8	4.7
28	"	4.0	3.3	4.0	3.8	3.8	4.2
29	"	2.8	4.0	2.8	4.0	3.2	—
30	"	4.0	4.0	4.0	4.0	4.2	4.5
Average		3.57*	3.88	3.59*	3.82	3.31*	3.90
31	Reg.	4.0	4.0	3.8	3.5	3.0	3.8
32	"	3.5	3.8	3.5	3.8	3.5	3.5
33	"	3.3	4.0	4.0	3.5	5.0	4.5

KEY: 1 Very poor; 2 Poor; 3 Fair; 4 Good; 5 Very good.

* Indicates Statistical Significance.

TABLE VI

AVERAGE BREAK EVALUATION BY PLANT SORTERS

Side Leather

Side Number	Level of Pancreatic Product	After Staking (average of 2)		After Buffing (average of 2)		After Finishing (average of 4)	
		Test	Control	Test	Control	Test	Control
1	Low	2.0	3.5	3.0	3.0	2.0	3.0
2	"	2.5	2.5	2.0	2.5	1.0	1.3
3	"	3.5	4.0	3.5	4.0	3.0	4.0
4	"	3.5	4.0	4.0	4.0	2.0	4.0
5	"	2.5	3.0	3.0	3.0	1.3	2.7
6	"	3.5	3.0	3.0	3.0	2.3	2.7
7	"	3.0	3.5	3.5	3.5	3.3	5.0
8	"	4.0	4.0	4.0	4.0	3.3	4.7
9	"	3.0	4.0	3.0	4.0	1.3	4.7
10	"	3.5	3.5	3.5	3.5	2.0	3.7
11	Medium	3.5	4.0	4.0	3.5	3.0	4.3
12	"	3.0	3.5	3.0	3.0	2.0	3.0
13	"	3.5	4.0	4.0	4.0	3.7	4.3
14	"	3.0	3.5	3.0	3.5	1.7	4.3
15	"	3.5	4.0	3.5	3.5	3.7	4.0
16	"	3.5	—	4.0	—	4.7	—
17	"	3.5	3.0	3.0	4.0	3.0	5.0
18	"	3.5	4.0	3.5	3.5	3.0	3.7
19	"	4.0	4.0	4.0	4.0	2.0	3.7
20	"	3.5	3.5	3.0	4.0	2.7	3.7
21	High	3.5	4.0	3.5	4.0	3.0	4.7
22	"	3.5	3.5	3.5	4.0	3.7	4.3
23	"	3.5	3.5	3.5	3.5	3.3	2.7
24	"	3.5	4.0	4.0	4.0	3.0	3.3
25	"	3.0	4.0	3.5	4.0	1.7	4.3
26	"	3.5	4.0	3.5	4.0	3.3	4.0
27	"	2.5	3.5	3.0	3.0	1.0	4.0
28	"	2.5	3.0	3.0	3.5	2.3	4.7
29	"	3.0	4.0	3.0	3.5	3.0	—
30	"	3.5	4.0	4.0	4.0	3.7	4.7
Average		3.24**	3.66	3.38**	3.62	2.55**	3.88
31	Reg.	3.5	3.5	3.0	3.5	3.0	2.7
32	"	4.0	4.0	4.0	4.0	3.3	4.7
33	"	3.0	4.0	3.5	4.0	4.7	5.0

KEY: 1 Very poor; 2 Poor; 3 Fair; 4 Good; 5 Very good.

** Indicates Statistical Significance at .01 level.

TABLE VII

AVERAGE SELECTION EVALUATION BY PLANT SORTERS

Side Leather

Side Number	Level of Pancreatic Product	After Staking (average of 2)		After Buffing (average of 2)		After Finishing (1 only)	
		Test	Control	Test	Control	Test	Control
1	Low	3.0	2.5	1.5	1.5	2.0	3.0
2	"	2.0	2.5	3.0	1.5	2.0	1.0
3	"	3.0	2.0	2.0	3.0	3.0	3.0
4	"	2.5	2.5	3.0	2.0	1.0	1.0
5	"	2.5	1.5	1.5	1.0	1.0	2.0
6	"	2.0	2.5	3.0	2.5	2.0	3.0
7	"	3.0	3.5	2.0	2.5	3.0	4.0
8	"	1.5	1.0	2.5	3.0	2.0	1.0
9	"	2.0	2.0	2.0	1.5	1.0	1.0
10	"	2.0	2.5	2.0	3.0	2.0	2.0
11	Medium	2.5	3.0	2.0	2.5	1.0	3.0
12	"	3.0	2.5	3.0	2.5	2.0	1.0
13	"	2.0	1.5	1.0	1.5	1.0	2.0
14	"	3.0	2.0	3.5	2.5	3.0	4.0
15	"	3.0	3.0	4.0	4.0	2.0	2.0
16	"	3.5	—	3.0	—	2.0	—
17	"	3.0	2.5	2.5	3.0	3.0	1.0
18	"	2.0	2.5	1.5	2.5	2.0	2.0
19	"	4.0	3.0	2.5	2.5	1.0	2.0
20	"	2.0	1.5	2.5	1.5	1.0	1.0
21	High	3.0	3.0	2.5	3.0	3.0	3.0
22	"	2.0	2.5	1.5	2.0	1.0	2.0
23	"	3.0	2.0	2.5	2.0	2.0	2.0
24	"	2.0	3.0	1.5	3.0	1.0	3.0
25	"	3.0	3.5	2.5	3.5	2.0	3.0
26	"	3.5	2.5	4.0	3.0	3.0	2.0
27	"	3.0	2.5	2.5	2.0	1.0	3.0
28	"	3.0	1.5	1.5	1.0	1.0	1.0
29	"	2.5	3.0	1.5	3.0	1.0	—
30	"	3.0	1.5	2.0	1.5	2.0	1.0
Average		2.62*	2.38	2.31	2.38	1.82	2.11
31	Reg.	2.0	2.5	2.0	1.0	2.0	3.0
32	"	2.5	2.0	2.5	3.0	3.0	3.0
33	"	3.0	1.0	1.5	1.5	2.0	1.0

KEY: 1 to 4 are best to reject.

* Indicates Statistical Significance.

TABLE VIII

DRAWN GRAIN AND VEININESS EVALUATION BY PLANT SORTERS

Side Leather in the Crust

Side Number	Level of Pancreatic Product	1st Sorter Test	1st Sorter Control	2nd Sorter Test	2nd Sorter Control
1	Low	DG	DG	3.0	3.0
2	"	DG	DG	3.0	4.0
3	"	DG	DG	2.0	1.0
4	"			2.0	1.0
5	"	DG	DG	5.0	2.0
6	"		DG	3.0	2.0
7	"	DG		2.0	3.0
8	"			1.0	2.0
9	"	DG	DG	3.0	2.0
10	"	DGV	DG	2.0	2.0
11	Medium	DG		2.0	2.0
12	"	DG	DG	4.0	3.0
13	"	DG		2.0	1.0
14	"			1.0	2.0
15	"	DGV	DG	3.0V	2.0
16	"	V	No Sample	1.0	No Sample
17	"			3.0	1.0
18	"	DG		2.0	1.0
19	"			2.0	1.0
20	"	DG		3.0	2.0
21	High	DG		3.0	1.0
22	"	DG	DG	3.0	3.0
23	"	DG		3.0	3.0
24	"			2.0	1.0
25	"	DG	DG	5.0	2.0
26	"	DG		3.0	2.0
27	"	DGV		5.0	3.0
28	"	DG		5.0	4.0
29	"	DG	DG	3.0	2.0
30	"	DGV		2.0	1.0
Average				2.86*	2.03
31	Reg.	DG		2.0	2.0
32	"	DG		2.0	1.0
33	"	DG		3.0	1.0

KEY: 1 to 5 increasing drawn grain.
* Indicates Statistical Significance.
DG: Drawn Grain
V: Prominent Veins

TABLE IX

AREA OF LEATHER

Finished Side Leather

(Square feet per side)

Side Number	Level of Pancreatic Product	Test	Control
1	Low	17.50	18.00
2	"	19.50	16.50
3	"	20.50	19.25
4	"	20.75	22.50
5	"	18.00	18.00
6	"	18.50	16.50
7	"	17.00	18.75
8	"	21.50	17.25
9	"	19.50	20.50
10	"	18.00	16.50
11	Medium	15.00	18.00
12	"	20.00	16.50
13	"	17.25	18.00
14	"	19.00	19.00
15	"	19.25	21.00
16	"	19.50*	No Sampl
17	"	17.25	15.25
18	"	20.25	19.50
19	"	16.25	16.25
20	"	20.50	20.00
21	High	19.50	18.00
22	"	16.25	16.25
23	"	19.25	18.00
24	"	20.00	19.50
25	"	18.50	20.50
26	"	20.50	21.00
27	"	18.25	19.50
28	"	19.00	17.25
29	"	16.25*	No Sample
30	"	19.25	20.25
Average		18.79	18.48
31	Reg.	18.50	17.50
32	"	17.00	19.00
33	"	16.25	16.75

*These sides not considered in the average.

complete deliming as used for all the test and control sides as compared with the regular bating procedure. Values for these sides were not used in any of the interpretations which follow. Rank analysis of differences between pairs over the whole population was used to determine significance.

As shown in Table V the plant sorters decided that temper was better (firmer) for control sides in the crust after staking, after buffing, and for the finished leather. Laboratory measurement of temper as shown in Tables III and IV showed this same tendency but not at significant levels. It is possible that had we had the complete side distribution as used for previous correlation studies we might have agreed more exactly.

In Table VI the results show that break was better for the control sides than for the test sides. Laboratory measurement of break as shown in Tables III and IV tended to show the opposite although not usually at significant levels.

Plant evaluation of selection is concerned mostly with natural defects but may be influenced by veins, fat wrinkles, ribbiness, rough grain, etc., which may have been affected by removal of elastic tissue. A significant difference in the results shown in Table VII is found only for the crust leather after staking. In this leather the control sides gave a better selection than the test sides, but for the other two groups the opposite was true, although not at significant levels.

In Table VIII the two sorters used different ways to express the degree of drawn grain, but in both cases it is obvious that the control sides had less drawn grain than the test sides. This may reflect the extra drumming which the test sides received during pancreatic product treatment. Only a few sides were noted (with the letter V) as having prominent veins, but these were all among the test sides.

TABLE X

ANALYSIS OF FINISHED LEATHERS

Side Leather

	Control (Regular Enzyme, Special Deliming)	Pancreatic Product Level		
		Low	Medium	High
Moisture	13.07	13.44	13.16	13.21
Chloroform Extract (MFB)	3.89	3.93	3.83	4.07
Hide Substance (MFB)	81.00	80.19	78.95	78.48
Total Ash (MFB)	4.69	4.86	4.73	4.75
Chrome Oxide (MFB)	4.10	4.14	4.04	4.04
pH	3.40	3.40	3.43	3.44

The area of all the sides was measured, and the results are shown in Table IX. No significant difference was shown between the test and the control sides. The assumption was made that the two sides in each pair had the same area before pancreatic product treatment.

Results of the chemical analysis of the leathers produced in the plant tests are shown in Table X. It is noted that there is little difference in chemical composition of the regular production side leather in comparison with the chemical composition of the side leathers which were prepared from low, medium, and high pancreatic product treatments.

CONCLUSIONS

The removal of elastin from hides under the specific conditions used affected the properties of the leather produced.

1. The evidence from plant grading shows that treatment with the special pancreatic product reduces the temper of side leather, although this is not borne out by laboratory testing of a single position in each side.

2. Plant gradings of side leather agree that treatment with the special pancreatic product produces a coarser break than does regular bating practice.

3. Plant gradings of side leather agree that treatment with the special pancreatic product produces more drawn grain than does regular bating practice.

4. Physical tests indicate that treatment with the special pancreatic product has improved fiber strength of side leather as shown by stitch tear, tensile strength, and increased force required to stretch the leather.

5. Physical tests indicate that treatment with the special pancreatic product has improved the grain properties of side leather as shown by higher Mullen pressure at grain crack and by less force required to stretch the grain than for either the corium split or the full thickness of the leather.

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